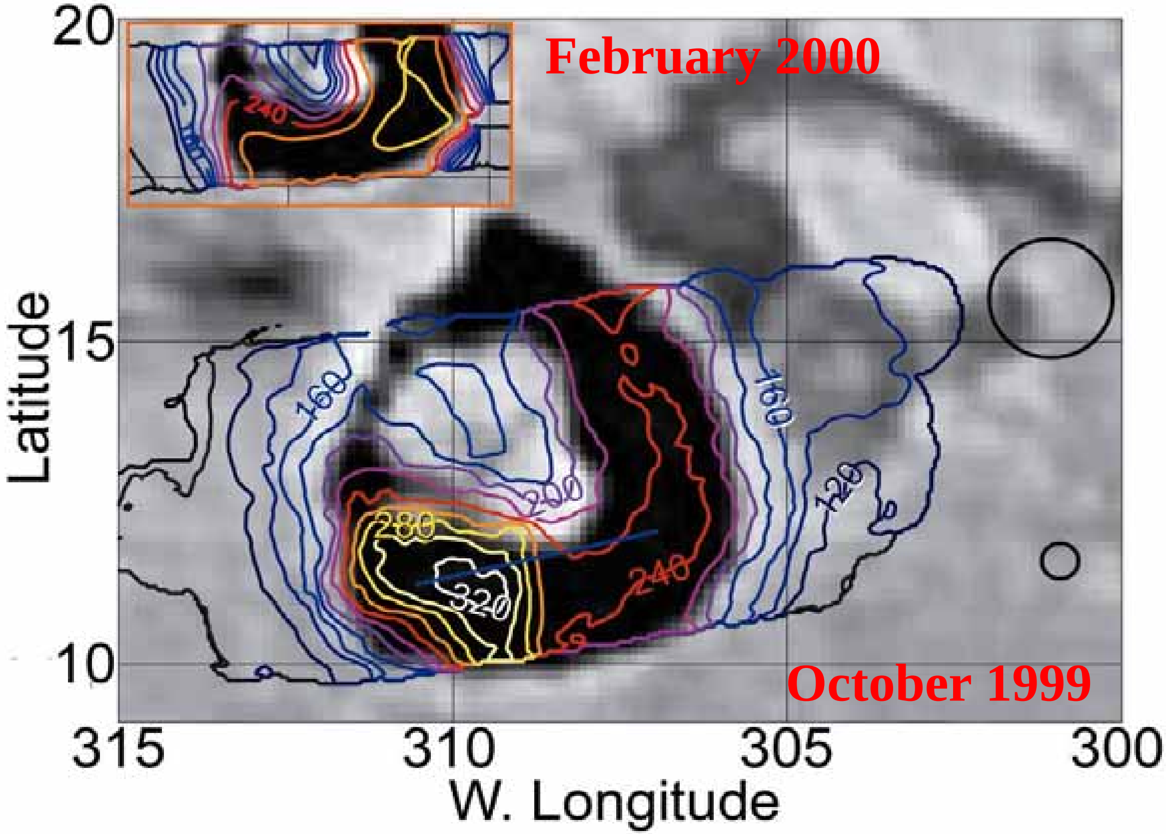
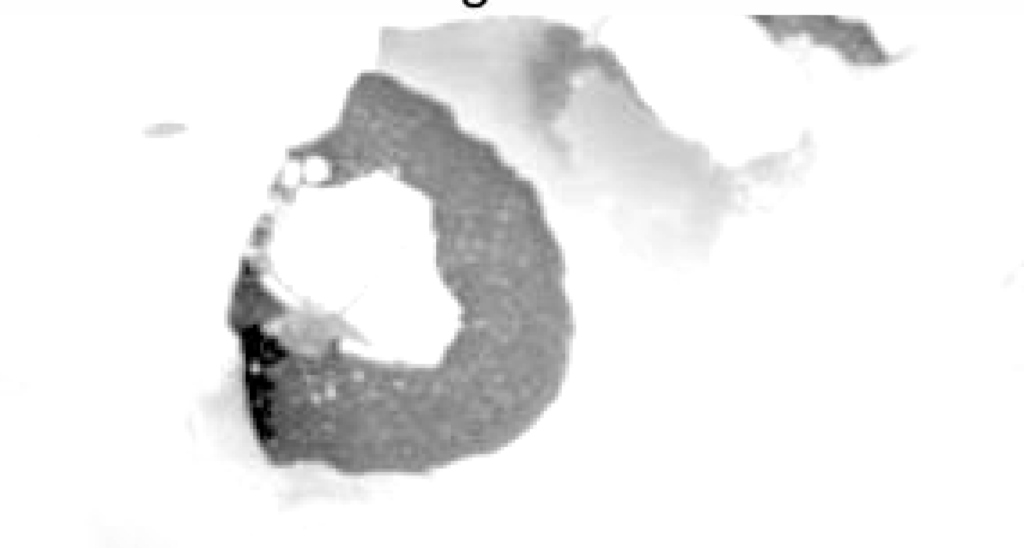
PPR & Voyager data show wave





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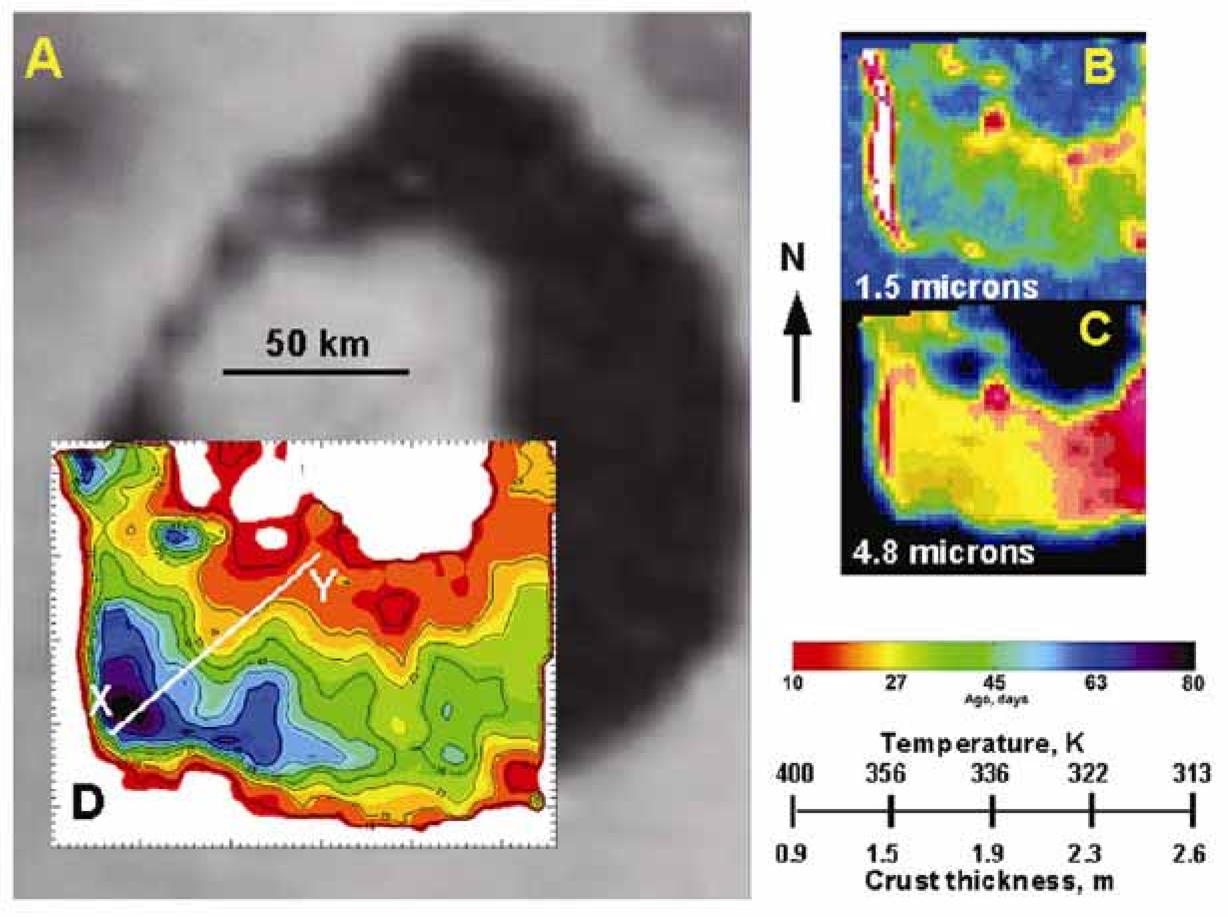
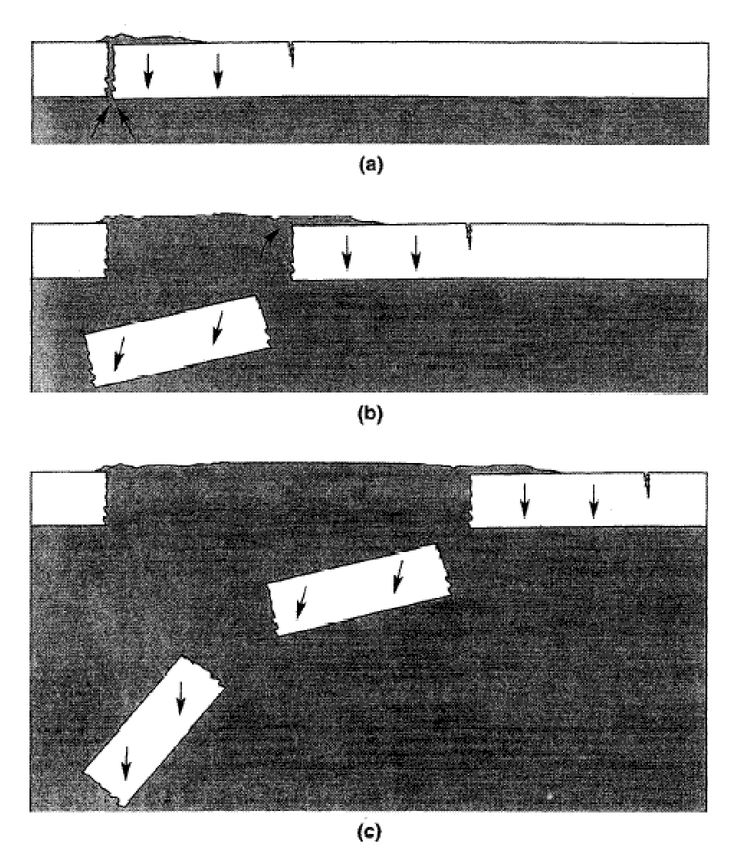
NIMS, too



I32 data from Davies, 2003

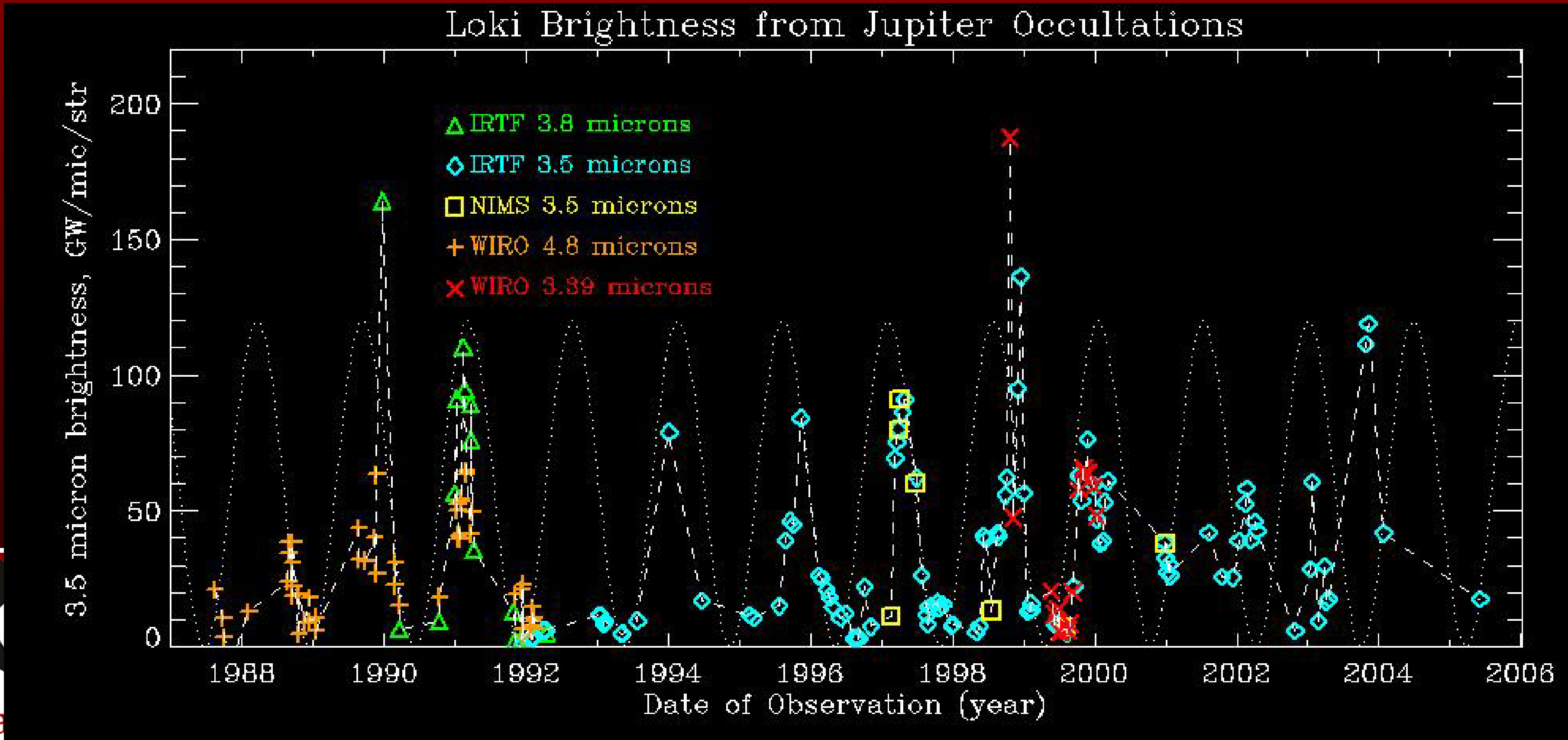
Proposed model (Rathbun et al, 2002)

- Loki is a lava lake
- As the crust cools and solidifies, it becomes negatively buoyant and sinks
- One piece sinks, causing the piece next to it to sink next, thus a resurfacing wave



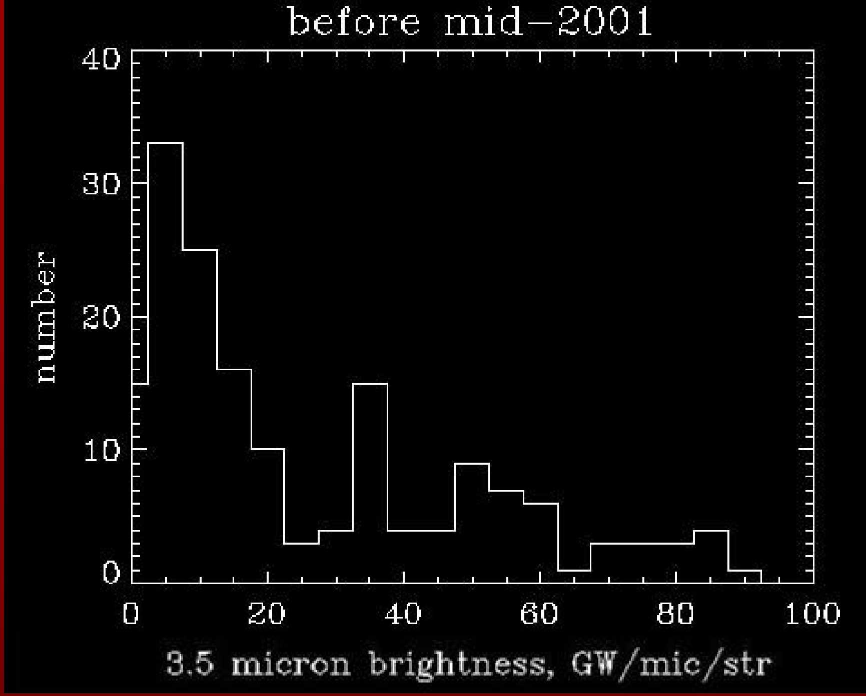
Groundbased observations

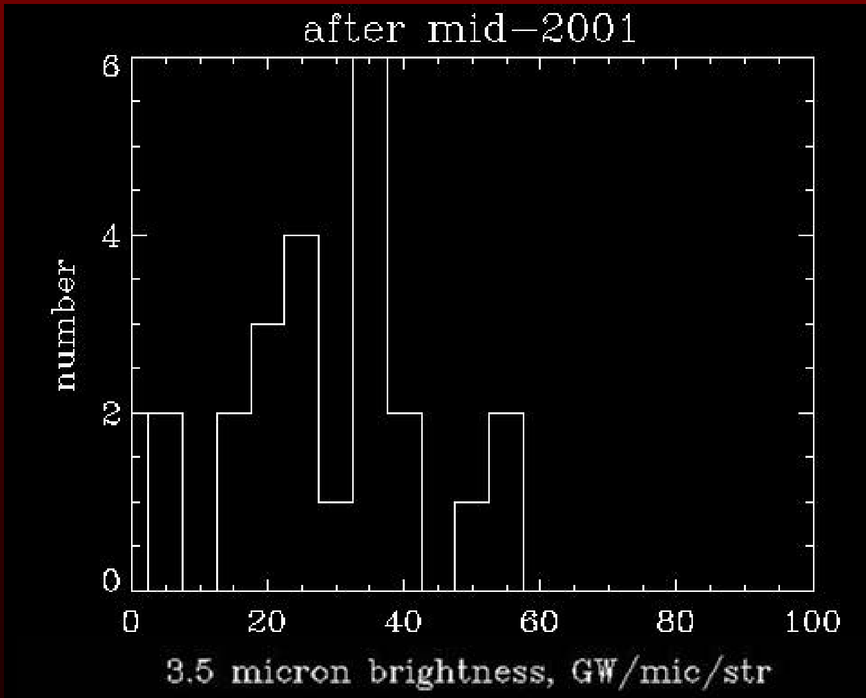
- This model qualitatively matches groundbased data which showed periodic brightening events (period 540 days)
- Brightenings occur periodically because of the amount of time it takes for the crust to become negatively buoyant



Behavior changes

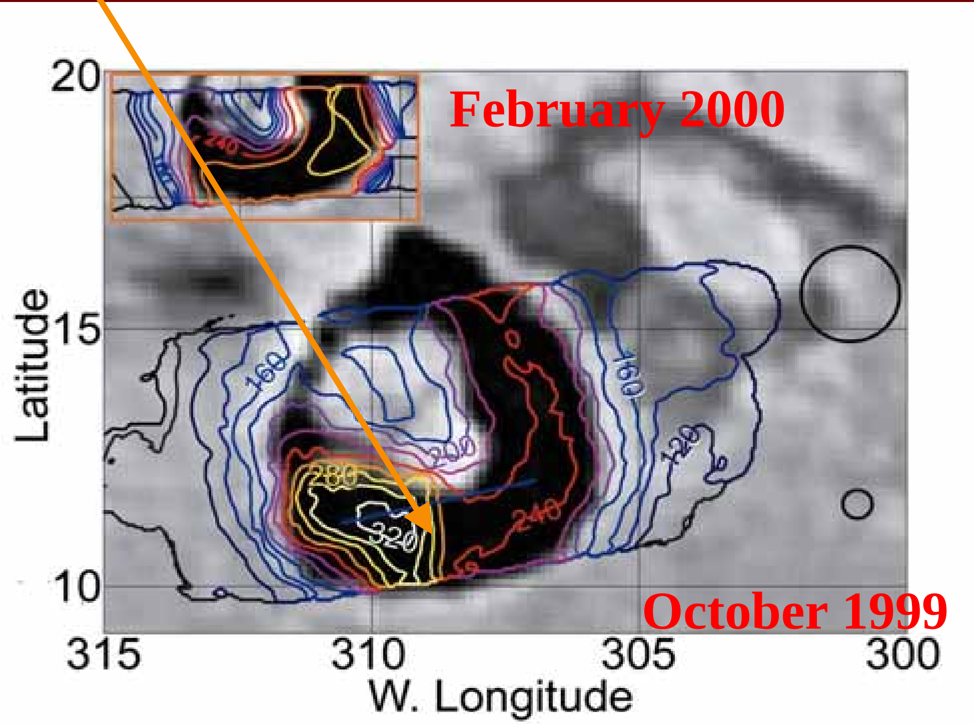
- Between 1988 and 2001
  - Two distinct populations of brightness seen, one high and one low
  - Brightenings occur periodically
- Between 2001 and 2004
  - Single brightness population at mid-level
  - No periodic changes in brightness seen
  - Lower maximum brightness





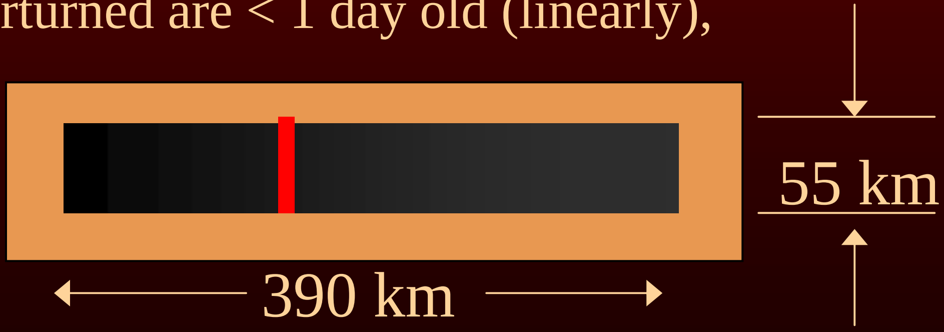
Model Motivation

- Overturning lake model was developed to match the low-temperature emission from the cooling patera
- Can it also match the high-temperature emission from the resurfacing front that (we think) dominates the integrated 3.5 micron flux seen from the ground?
- If so, we can learn more about the resurfacing process from the ground-based observations

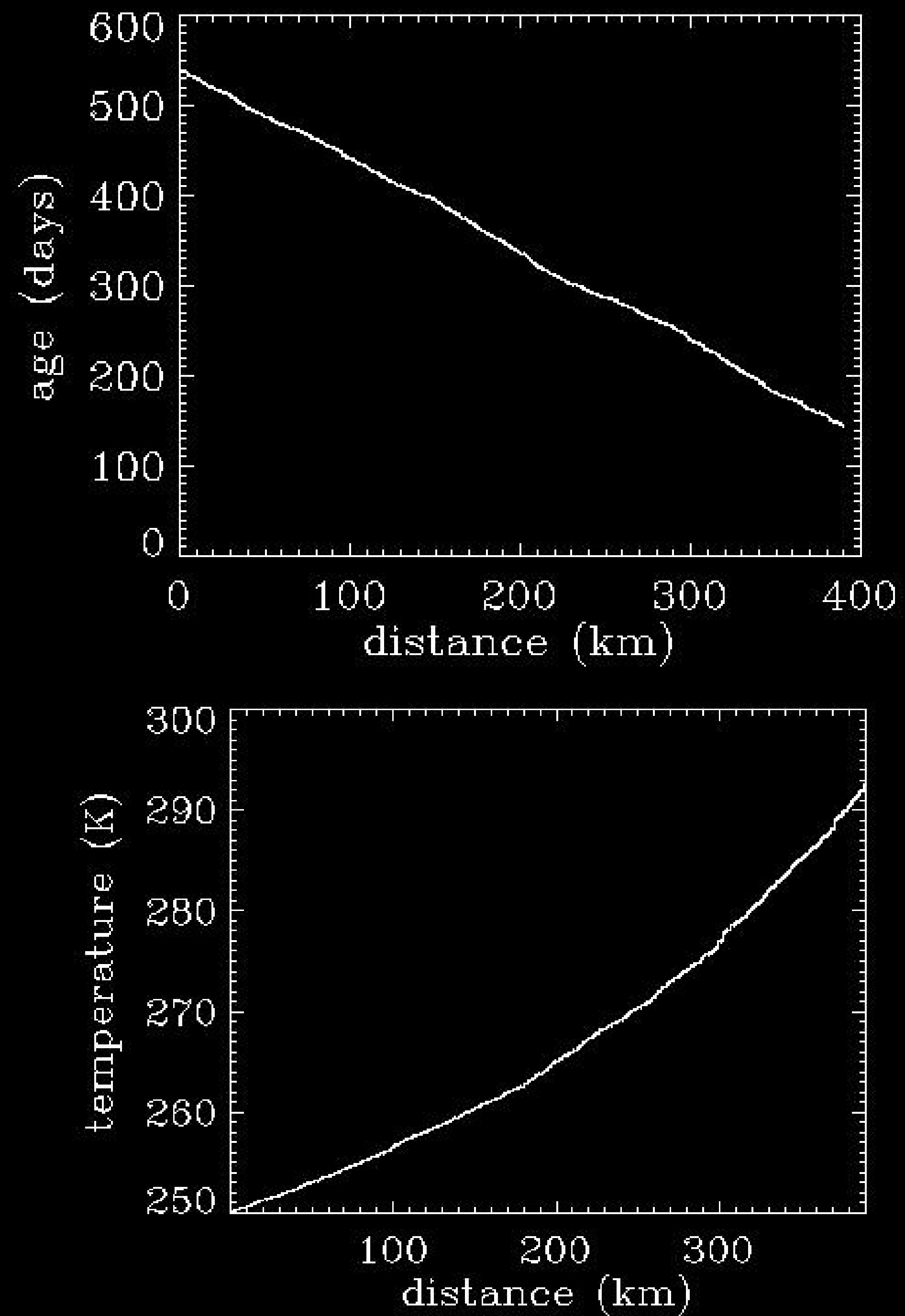


Quantification of model

- Area of dark material at Loki
  - 21,654 km^2
- Unroll to make a simple rectangular lava lake of same area
- Break up length into n rafts
  - Width = 55 km
  - Length = 390 km/n (approximately 1-10 m)
- Every day, some rafts overturn
  - Average # determined by wave speed (~1 km/day)
  - Areas in model where rafts overturned are < 1 day old (linearly), other areas age 1 day



- Calculate the temperature of each of the n rafts using Howell, 1997
  - $T(t) = 549\ K\ (t/\text{days})^{-1/8}$
- At the end of each day, calculate the total brightness of the lava lake assuming blackbody emission



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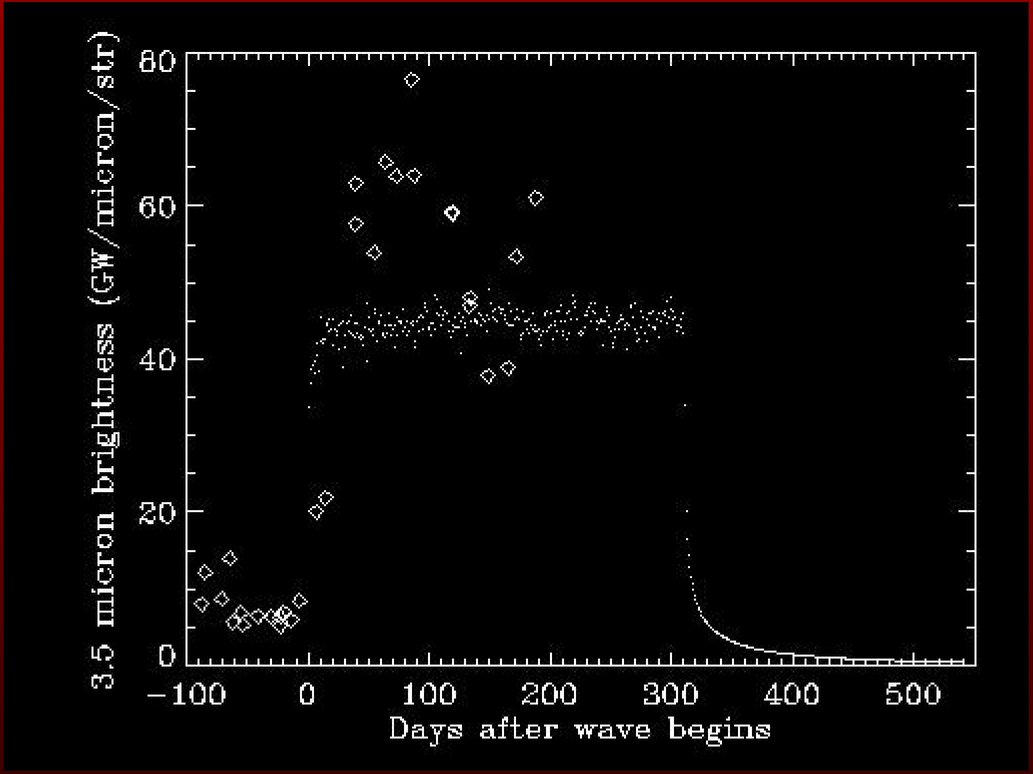
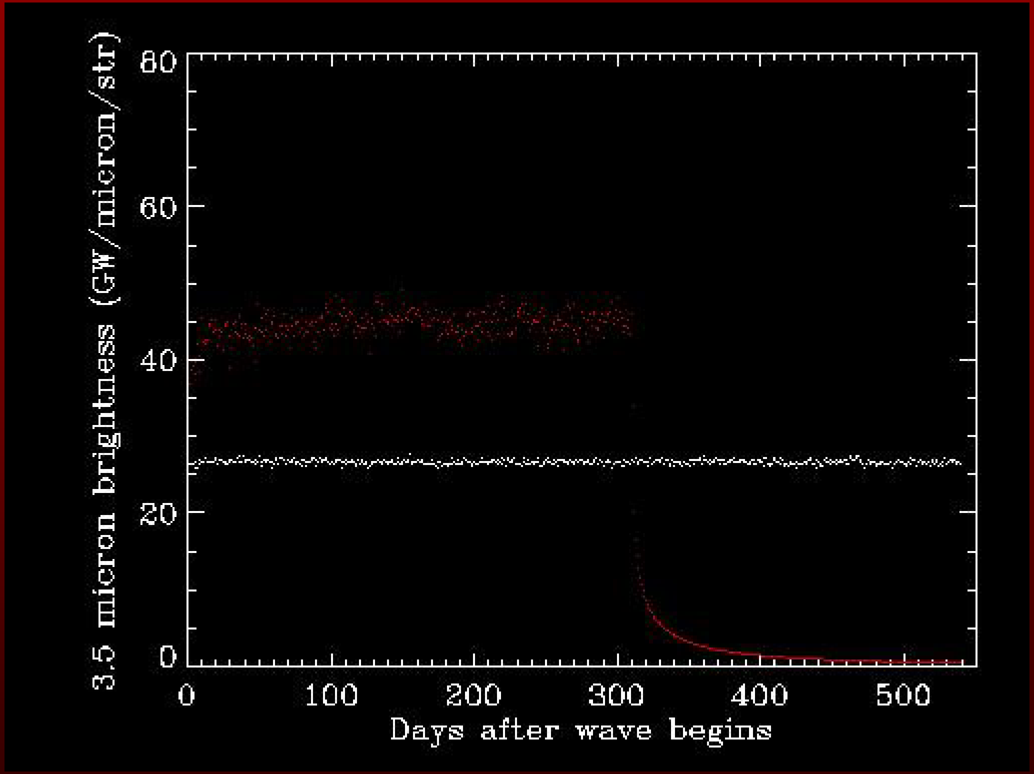
Model results

- v=1.3 km/day
- Two brightness populations
- Approximately
  - 310 days bright
  - 230 days dim
- Ramp up similar to that seen in 1999-2000 brightening



Model results 2

- v=0.7 km/day
- Every day high brightness
- Highest brightness lower than in previous case
- Brightness = speed x 36



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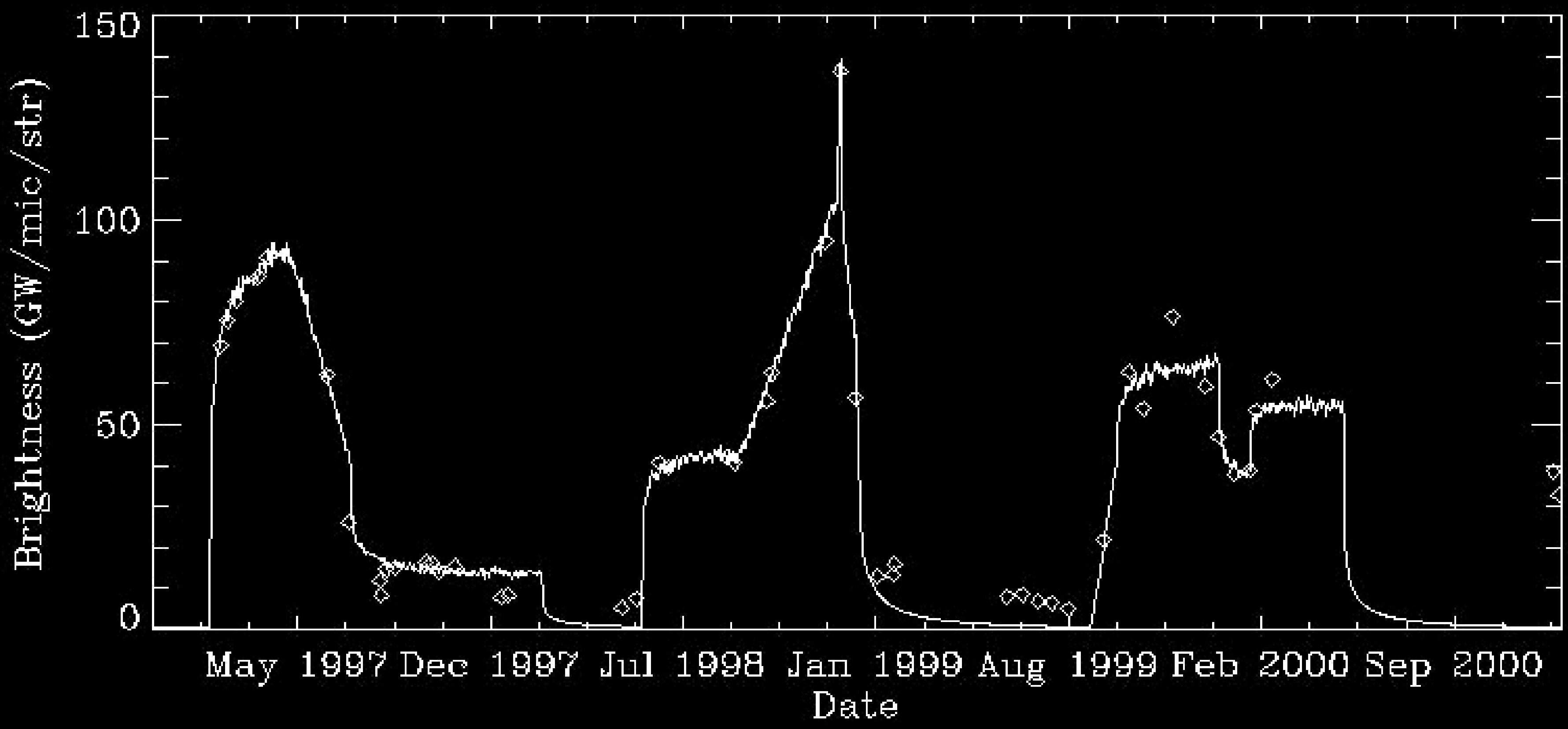
Three brightening events (best data)



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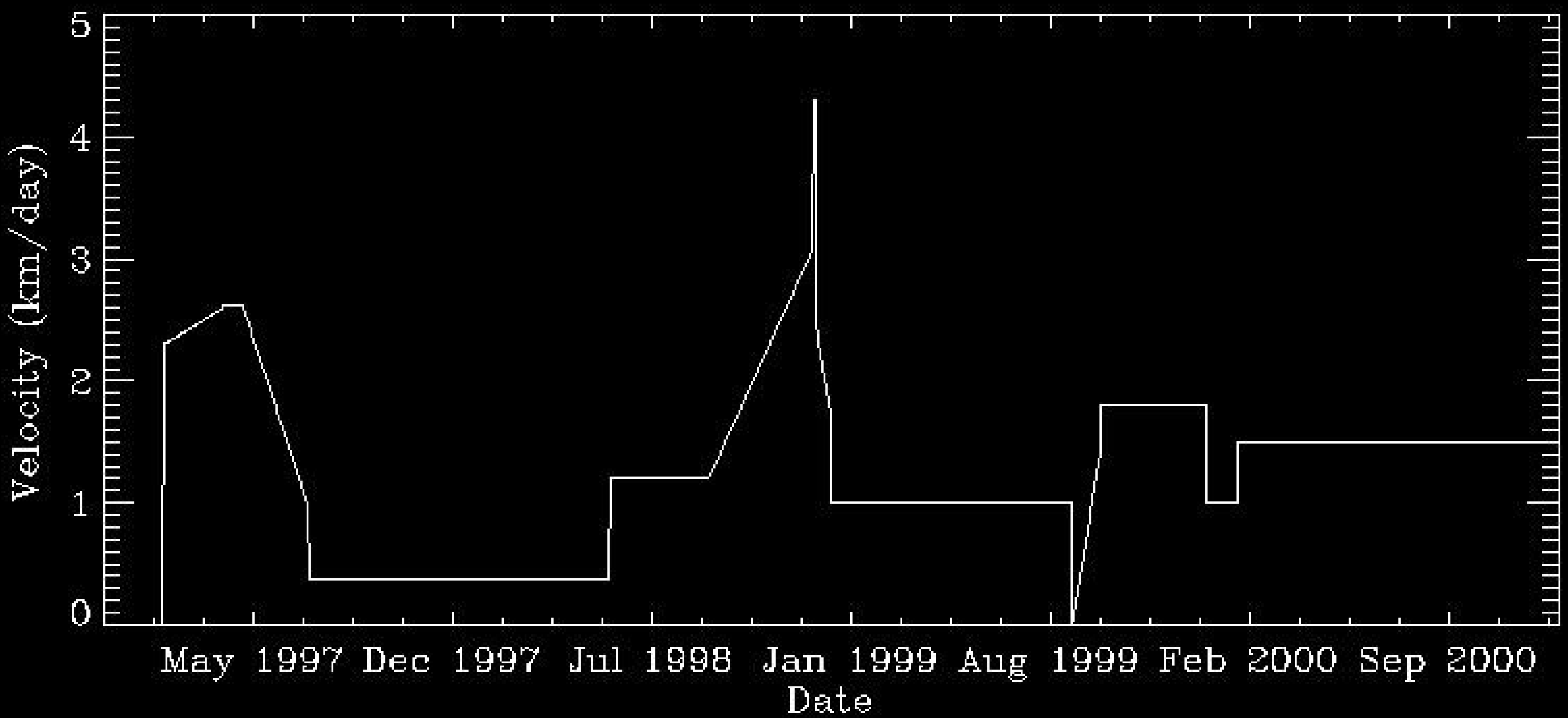

5
4
3
2
1
0
Velocity (km/day)
May 1997
Dec 1997
Jul 1998
Jan 1999
Aug 1999
Feb 2000
Sep 2000
Date

Conclusions?

- So, changes in the velocity with which the overturn happens can explain the changes in brightness and the changes in periodic behavior
- But, what causes the velocity to change?

Density

- Model can be used to determine age of raft at overturn
- Age varies from 300-600 days from 1997-2000
- Originally proposed that overturn due to crust becoming overdense
- So, what is the density of the crust at this age?
- Using porosity model and cooling model densities vary from 2405 kg m-3 to 2420 kg m-3
- Even if a raft doesn't sink until it is 1000 days old, its density is only 2433 kg m-3

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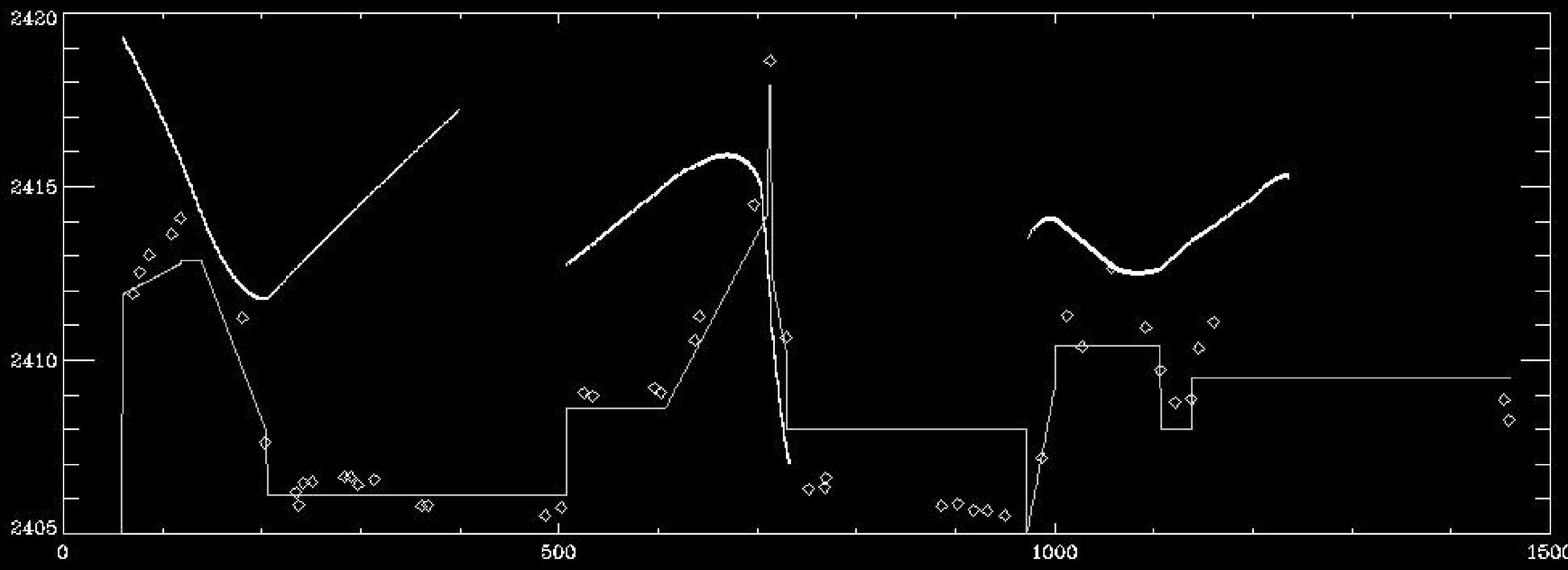
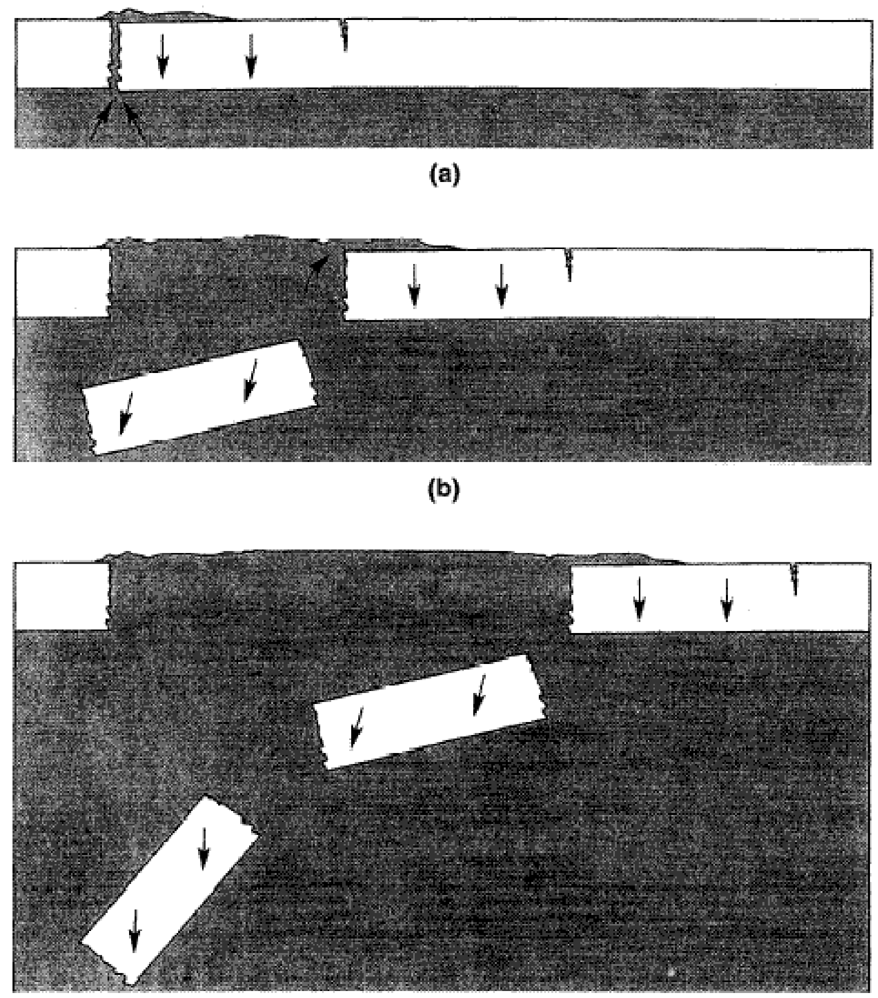
1% difference in density yields 100% difference in age




(a) (b) (c)